Remarks

Applicants respectfully request reconsideration of the present application in view of the foregoing amendments and the following remarks. Claims 1, 3-16, 18, 21, 23, and 24 are pending. Claims 1, 11, and 15 are independent. No claims have been allowed. Claims have been amended, all for reasons not necessarily related to patentability. The amendments herein do not necessarily narrow the claims. No new matter has been added. These rejections are respectfully traversed.

Cited Art

Tyrrell *et al.*, "CSP Methods for Identifying Atomic Actions in the Design of Fault Tolerant Concurrent Systems" (Tyrrell) and Reps et al., "Precise Interprocedural Dataflow Analysis via Graph Reachability" (Reps).

Telephonic Interview

Applicants wish to thank the Examiner for extending a telephonic Examiner Interview on August 13, 2008. Claim 1, and the cited art to Tyrrell and Reps were discussed. Although specific agreement was not reached, Applicants now present reasoned arguments in light of the Examiner's description of the prior art and the claim language.

Claim Rejections under 35 U.S.C. § 112

The Action rejects claim 23 under 35 U.S.C. § 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which Applicants regard as the invention. Applicants respectfully disagree with the Action's reasoning, but to expedite prosecution, have amended claim 23, rendering the rejection moot. The Amendment is supported in the Specification and Figures as originally filed. In addition, the following example of support in the Specification, at page 12, lines 17-27, is given; reproduced below.

> In any of the examples described herein, a procedure summary can include one or
> more indications of a location within the procedure. For example, the procedure
> summary can indicate an initial location and a resulting location in the procedure. In
> such a case, the summary summarizes actions for the procedure starting at the initial
> location and ending at the resulting location. In some cases, execution may loop, so it is
> possible for a resulting location to be before the initial location in the code. Such
> locations are sometimes called the "program counter" because they reflect a modeled

value of a program counter executing the procedure.

Inclusion of the initial and resulting locations can help in piecing together partial summaries. In such a case, the initial and resulting locations may not correspond to the beginning or end of the procedure being summarized. [Specification, page 12, lines 17-27.]

For at least this reason, Applicants request that the claim 23 rejection under 35 U.S.C. § 112 be removed.

Claim Rejections under 35 U.S.C. § 103

The Action rejects claims 1 and 3-16, 18, 21, and 23-24 under 35 U.S.C. § 103(a) as being unpatentable over Tyrrell in view of Reps.

Claim 1.

Not All Features Taught or Suggested.

Tyrrell does not teach or suggest the claim 1 language:

1) identifying a at least one plurality of the actions within the procedure as atomically modelable with respect to multithreaded execution of the procedure as atomically modelable actions,wherein the atomically modelable actions are not subject to interruption by other threads.... [Emphasis added.]

Tyrrell's description of an atomic action that stretches through a group of processes teaches away from identifying atomic actions within a single procedure. Rather, Tyrrell includes special constructs (exit and entrance lines) used to determine the atomic actions across procedure boundaries. This can be seen in the following quote, which explicitly discusses multi-process boundaries used to define the bounds of the Tyrrell-defined atomic action.

"The mechanism is bounded by an entry line, an exit line and two side walls which completely enclose **the set of interacting processes** which are party to the mechanism, and across which interprocess interactions are prohibited." [Tyrrell, page 630, paragraph 1, emphasis added.]

Further, special acceptability tests for each of the processes participating in the atomic action are provided for, as is a special synchronous exit. "Only if all participating processes pass their respective acceptability tests is the mechanism deemed successful and all processes exit, in synchronism, from the action." These special constructs used to define atomic actions across processes

(exit points, entry points, acceptability tests, synchronous exit from all "atomic" processes) strongly teach against atomic actions being defined within a single process, as if all the actions were within a single process, the tests would not be necessary.

The requirement in Tyrrell that atomic actions are defined **across processes** is further reinforced by the requirement that it is necessary "to identify a boundary within the state space of the **complete set of processes** across which error propagation by communication is prevented." [Tyrrell, page 630, col. 1, last para.]   Even more tellingly, "such a boundary **of necessity** prohibits the passing of information to any process not involved in the atomic action and similarly embraces all interacting processes within the atomic action." [*Id.* Emphasis added.]   Clearly, the system of Tyrrell requires that atomicity be determined between processes, to, at a minimum, "prohibit[] the passing of information to any process not involved in the atomic action." [*Id.*]

As such, Tyrrell teaches against determining atomicity within a single process. This strongly teaches against the claim 1 language "1) identifying at least one plurality of the actions within the procedure as atomically modelable with respect to multithreaded execution of the procedure as atomically modelable actions, wherein the atomically modelable actions are not subject to interruption by other threads...."

As a further reason for patentability, neither Tyrrell nor Reps teaches or suggests the claim 1 language:

> 2) generating the <u>at least one</u> partial procedure summary of the procedure from
> the atomically modelable actions....[Emphasis added.]

The action cites to parallel processing and interleaving summaries shown in Tyrrell, page 633, Figures 2,3, and 4, to teach or suggest.   [Action, page 4.]   Tyrrell does show an example of determining atomic actions for three processes. [Tyrrell, page 633, cols. 1 and 2.]   However, the atomically modelable actions in Tyrrell explicitly extend to multiple processes. "Hence the atomic actions enclosing event c1 includes processes P1 and P2, begins immediately after event a1 in process P1 and event b1 in process P2, and terminates immediately before event a2 in process P1 and event b2 in process P2." [Tyrrell, page 633, second col., first full paragraph.]

Thus, Tyrrell explicitly describes a method to determine atomic actions as the actions interweave through different processes. This requirement that different processes be considered to determine the atomic actions clearly and explicitly teaches against the claim 1 language "generating

the <u>at least one</u> partial procedure summary of the procedure from the atomically modelable actions, wherein the <u>at least one</u> partial procedure summary comprises at least one state pair, wherein the at least one state pair models an initial state and a resulting state of <u>the</u> atomically modelable actions; [Emphasis added.]

The Action admits that Tyrrell does not explicitly disclose "performing a reachability analysis of at least a portion ... of the multithreaded software...." However, the Action then states that Reps does so cite. [Action, page 4.] Applicants respectfully disagree and traverse. Reps describes a system which does not mention functioning in the context of multithreaded programs. For example, the description of Reps does not take into account any sort of multithreading, as far as applicants can tell. Moreover, Reps does not consider the concept of "atomic actions," as such actions do make sense when dealing with single threads. As the reference to Reps does not consider either multi-threaded applications or atomic actions, Reps teaches away from "performing a reachablity analysis of at least a portion ... of the multithreaded software...." For at least this further reason, claim 1 is in condition for allowance.

No Reason to Combine.

As an additional reason for allowance, it is improper to combine Tyrrell with Reps. As the reason to combine, the Action states: "It would have been obvious to one of skill in the art at the time of the invention to utilize the reachability analysis of Reps with the atomic modeling of multithreaded execution of Tyrrell in order to allow for precise analysis." [Action, page 5.]

Initially, Applicants would like to point out that Tyrrell discusses performing a reachability graph using only a specific construct, a Petri net, only when an extremely specific set of qualifications are met. Even though Tyrell states that "atomic actions are identified in parallel processing systems," [Tyrrell, abstract], the communications within parallel processing systems must be of a very specific sort; that is, they must be synchronous and atomic and, further, the communications are forced into "mutual synchronization at communication points," as can be seen from the Tyrrell quote, below.

"By only permitting synchronous, atomic, communications, occam forces communicating processes into mutual synchronization at communication points. This not only imposes a strict discipline on the designer (because errors in the synchronization logic and lead to deadlock) but also leads to a system more amenable to analysis. ....
[Tyrell, page 630, second column, last paragraph.]

Moreover, the method of defining atomic actions requires the following steps:

1) translation of a existing textual occam design into a graphical Petri net;

2) translation between the graphical petri net and set theory or matrix-based methods for reachability analysis.

3) translation of the identified atomic action entry and exit points back to the original occam design.... [Tyrrell, page 631, second paragraph.]

Tyrrell admits that such a method creates serious problems:

4) for all but the simplest examples, there is a computational explosion which could restrict the analysis. [Tyrrell, page 631, first column, second paragraph.]

In Tyrrell, to determine atomicity, there are even more constraints:

It is not practicable to create the complete set of traces unless the set of processes is subject to certain constraints:

1) The processes must terminate, or arrive at a previously reached state, in a finite number of steps, else the set of traces becomes infinite.

2) Where program flow is made dependent on the value of variable expressions, static analysis has to consider all possible values within the range of the variable expression, which may be infinite and lead to an infinite set of traces.

3) No. 2 precludes from analysis classes of loops where trace evaluation would have to evaluate loop guards, and also to use of subscripted communication channels where the subscript is determined by a variable expression.

...

5) Interprocess communications occurring in loop constructs pose major problems for trace evaluation; in particularly (sic) if the loop iteration is controlled by a variable expression which is even indirectly determined by the real-world environment, then analysis can only be performed for special cases, i.e., where a subset of these environmental values are considered. [Tyrrell, page 631, second column, last paragraph to page 632, first paragraph.]

Reps does not consider the possibility of multi-threading, and so does not consider atomic actions, as all actions are assumed to be single-threaded, as far as applicants can tell. As Reps does not consider multithreading, it is unclear at best how Reps could be used in a system with the extremely large number of constraints related to multithreading found in Tyrrell, as listed above. Certainly, shoehorning a system (Reps) not intended for use in a multithreaded system which doesn't discuss atomicity would not lead to the claimed benefit, "precise analysis" [Action, page 5], as the specific sort of analysis performed in Terrell—determining atomicity across processes—is not even considered in

Reps, and so could not be made more precise by combining with an unrelated system.

Conclusion.

As not all features are taught or suggested, and as there is no convincing reason to combine the primary reference to Tyrrell with Reps, Applicants respectfully submit that claim 1 and its dependent claims 3-10, 21, and 23-24 are allowable over the cited art.

Claims 11-14.

Claim 11 is directed to a computer program product embodied on a first computer-readable medium and comprising code that, when executed, causes a computer to perform a method of modeling multithreaded software, and recites:

> 11.   (Currently Amended) A computer program product embodied on a first computer-readable medium and comprising code that, when executed, causes a computer to perform a method of modeling multithreaded software, the method comprising:
>   performing a reachability analysis of the multithreaded software;
>   during the reachability analysis, reaching a procedure;
>   analyzing actions of the multithreaded software within the procedure such that actions that can be executable atomically within the procedure are determined, wherein actions that can be executable atomically are not subject to interruption by other threads;
>   based on the analyzing, generating a plurality of partial procedure summaries for the multithreaded software, the plurality of partial procedure summaries comprising respective start and end actions for the determined actions executable atomically; and
>   during the reachability analysis, again reaching the procedure and reusing the plurality of partial procedure summaries to determine actions executable atomically;
>   wherein the partial procedure summaries comprises a plurality of modeled states of the multithreaded software for multithreaded execution of the multithreaded software. [Emphasis added.]

Not to belabor the point, but using the analysis shown in claim 1, it can be seen that neither Tyrrell nor Reps teach or suggest all of the elements recited in claim 11.

Since the cited references do not show all of the elements recited in claim 11, Applicants believe the claim is not subject to a 103 rejection and request the rejection be withdrawn.

Thus, Applicants respectfully submit that claim 11 and its dependent claims 12-14 are allowable over the cited art.

Claims 15, 16, and 18

Claim 15 is directed to a computer system for modeling multithreaded software, and recites:

15.   (Currently Amended) A computer-implemented system for modeling multithreaded software, the system comprising:

a model checker operable to analyze a model of the multithreaded software via checking the model of the multithreaded software for programming flaws, the model checker comprising:

the model of the multithreaded software,

wherein the model comprises:

a plurality of partial procedure summaries modeling beginning states and ending states of partial summaries of procedures within the multithreaded software during multithreaded execution of the multithreaded software, the partial procedure summaries comprising the start and end states of sets of actions within the procedures, the actions atomically modelable with respect to multithreaded execution of the software in that the atomically modelable actions will all be performed within a single procedure by a same thread; and

a reachability analyzer operable to employ the partial procedure summaries instead of the sets of actions to generate modeled states of the software. [Emphasis added.]

Not to belabor the point, but using the analysis shown in claim 1, it can be seen that neither Tyrrell nor Reps, either singly or in combination, teach or suggest all of the elements recited in claim 15.

Since the cited reference does not show all of the elements recited in claim 15, Applicants believe the claim is not subject to a 103 rejection and request the rejection be withdrawn.

Thus, Applicants respectfully submit that claim 15 and its dependent claims 16 and 18 are allowable over the cited art.

Support for Amendments

Support for the amendments can be found in the Specification and Figures as originally filed. In addition, the following examples of support are given: Specification, page 9, lines 7-20; Specification, page 13, lines 13-24.

Request for Interview

If any issues remain, the Examiner is formally requested to contact the undersigned attorney prior to issuance of the next Office Action in order to arrange a telephonic interview. It is believed that

a brief discussion of the merits of the present application may expedite prosecution. Applicants submit the foregoing formal Amendment so that the Examiner may fully evaluate Applicants' position, thereby enabling the interview to be more focused.

This request is being submitted under MPEP § 713.01, which indicates that an interview may be arranged in advance by a written request.

Conclusion

The claims in their present form should now be allowable. Such action is respectfully requested.

Respectfully submitted,

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